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A TREATISE ON OIL & GAS SEPARATION

by

WILLIAM Mc GRAW
AND E. H. ADAMS

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foreword

WE are endeavoring in this, our third bulletin on oil and gas separation, to give a more comprehensive treatment of the subject than has before been possible. We feel that this is possible because of the continued research into this matter and the widened scope of our experience since the last bulletin was issued in 1928. This broader field for investigation has been brought about by

(1) The use of equipment at higher pressures where the natural inherent horsepower of the wells could be used for delivery of gas under pressure.

(2) The production of large quantities of high gravity oil in such fields as Kettleman Hills, California, and

(3) The application of the most economical principles for conservation by the gas divisions of the various oil companies.

Again we wish to tender our sincere thanks to the oil companies who have aided us in compiling the data and who have faithfully assisted in the experimental work, and to those who have prompted the search for answers by propounding the questions.

Compliments of

Trumble Gas Trap Company

756 Subway Terminal Building

Los Angeles, California

Book Number **1237**

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CONSTRUCTION

CONSTRUCTION of separators is receiving more and more attention as the standard of oil field equipment is raised, because of the creation of Engineering departments, Standardization departments, and Safety departments within the oil companies. To keep abreast with the growing demand, the Trumble Gas Trap Company has given careful attention to the details of construction from the point of view of safety and simplicity of operation. A factor of safety of five is carried on all shells and the complete assembly is built with ample strength.

A redesign has just been completed and the models "R", "Q", "W", "I", and "T" are all built to conform with the A.S.M.E. code throughout. Of these models the "R" and "Q" are low pressure models having a maximum working pressure of 90 pounds and 115 pounds respectively. "W", "I", and "T" are high pressure models for 350 pounds, 525 pounds and 725 pounds.

The models "D", "V", "E", and "F" are an outgrowth of the older method of manufacture for oil field equipment but do not meet the A.S.M.E. specifications. This is because of the fusion welding used on housings, inlet and outlet connections, and manholes on the models "E" and "F". On the models "D" and "V" the shells are a completely fusion welded job. It is hoped that the manufacture of the welded models may eventually be eliminated so that the entire product can be brought to conform to the A.S.M.E. code throughout.

It may appear as though the writers were taking one side of a controversial question, but this is not intended. Many of the most experienced and best informed engineers of the world agree that supervised welding can produce a joint of as great efficiency as the best possible riveted joint. However, there is not the same possibility of strength fluctuation in the riveted joint *due to the human element* in comparison with the welded joint in commercial boiler shops. The American Society of Mechanical Engineers have made their rules after a careful study of the problem from every angle. The writers feel that this authority is sufficient to justify this stand.

Another item that has, in some cases in the past, received insufficient attention is the reinforcement of openings and the number of rivets in shear, to compensate for the material cut away to form the opening. Some equipment has been made, and possibly quite an amount, where the shell and longitudinal and circumferential joint were in accordance with best engineering practice, but openings and their reinforcing would

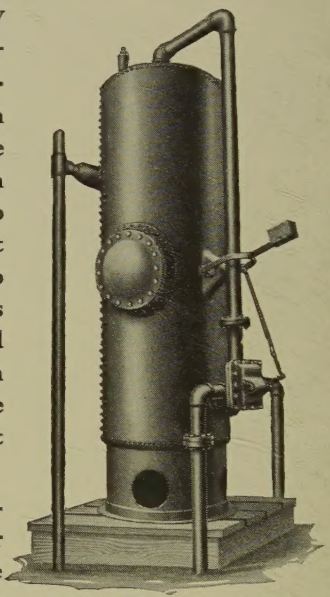
not meet a rigid inspection. The Trumble Company has not been free from this practice in the past.

The thickness of Trumble heads are all in conformity with the new A.S.M.E. formulae calling for a safety factor of 8.33 when elliptical heads are not used. Heads used on the model "I" and "W" are elliptical.

The location of the manhole on the separator may not appear an important item, but when we consider that a separator that has been in use must be cleaned and steamed out to expel all gas before it is safe to enter, the importance is easily seen. The manholes on separators should be so located that a float may be changed without making it necessary for a man to enter the receptacle.

In the past a closed type cylindrical or spherical float was used, and was built of heavy material where it was required to withstand heavy pressures. Such a float for pressure was heavy and cumbersome and had to be heavily counterbalanced to give it the necessary bouyancy.

The new Trumble float is equipped with a gas equalizing pipe that communicates the pressure to the inside of the float, and with this construction a large float can be used to secure the bouyancy, but the float is light enough to be easily handled. In addition to the equalizing pipe the floats on all separators except the models "D" and "T" are fitted with a blow off line that comes out through the float axle, and by means of the $\frac{3}{8}$" valve any condensate can be blown from the float during operation.



Model "F" Separator for maximum working pressure of 115 lbs. per square inch.

The importance of the method of introduction of the oil and gas into the separator is well known to those operators who have had to take a separator out of service because the entrained sand had cut a hole through the side of the separator. Separators constructed with this thought in the mind of the builder have a heavy bull plug into which the flow is first received, and the baffle for distributing the flow is backed by a wearing plate extending around the separator, and upon which the sand impinges, thereby protecting the shell.

The internal baffling of the separator has been perfected after years of operation and experimentation to determine the best means of separa-

tion. This experimental work has proven that the most effective separation is secured only when the entire body of incoming oil is spread out uniformly over the inner wall of the separator in as thin a film as is possible. This film flowing downwardly with each molecule of oil rolling over and over exposes the entire surface of the oil and allows practically all of the free gas to escape.

A further advantage of this method of baffling is the minimizing of the tendency to foam due to the oil reaching the oil body along the side walls of the separator. Many of us know the old method of filling the beer glass to eliminate some of the foaming, and this same principle applies with oil that has a tendency to froth.

In the case of large volumes of oil and gas some little gas that remains dissolved in the oil may be given up when it reaches the oil body if it is not too deeply submerged, and to assist this ebullition a deflecting ring is welded to the inner surface of the shell just below the oil body. This ring deflects the incoming oil in a horizontal plane across the top of the oil body where remaining gas bubbles can be more easily freed from the oil.

Construction of separators from the point of view of adjustment is as simple as it is possible to make them. The control on the low pressure separator is a single unit and the relative position of the gas ports and the oil ports is fixed and cannot be altered. The only adjustment that can be made is the raising or lowering of the oil level, and this is accomplished by a swivel nut on the connecting rod and need take only a minute or two to make the alteration.

The high pressure separators are equipped only with an oil control. The gas control is not necessary because pressure is always present in the separator to force the oil out. The adjustment again is one of change of oil level and is accomplished by the same means as that used on the low pressure separators. It should be borne in mind that a gas control is never necessary on a separator when there is sufficient steady pressure on the separator to overcome the pressure drop or loss in the oil line to the tank — plus the head of oil in the riser line to the top of the tanks. This may vary from a few pounds to several hundred pounds depending on the installation.

INSTALLATION

SEPARATOR installations are varied in relation to the uses, quantities of oil and gas, number of separators, location of the well in relation to receiving tanks, disposition of gas, etc., but there are some general rules that apply under all conditions. One of these is the arrangement with by-pass connections so that the separator may be cut out, if, for any reason it should become advisable. In making these by-pass connections, it is well to have the union connections between the by-pass valves and the separator so that the complete separator may be removed without disturbing the well.

Where two or more separators are used in parallel, the installation as shown in Figure (1) is recommended in order to assure equal division of load between the separators.

An emergency gas relief line should be connected to each separator. This relief line should be fitted with an emergency relief valve set at a relieving pressure a few pounds per square inch higher that the pressure carried on the gas gathering system, and this relief should be open to the atmosphere. In case of the absorption plant shutting down, or the gathering system failing to function for any reason, the gas pressure on the separator builds the remaining few pounds to the relieving pressure of the emergency relief valve, and then automatically flows off to the air. In this connection it is desirable that one or more "Two-way" tank valves be installed on the oil line to preclude the possibility of shutting the well into the separators while switching tanks.

Single Trap Installations.

Where a single separator is used on a well, and where no vapor recovery system is used on the oil receiving tanks, it is well to operate the separator at as low pressure as possible. The reason for this is that a certain amount of gas remains dissolved in the oil body under pressure, and this amount of dissolved gas increases with the pressure on the separator. (See graph in Fig. 2.)

In consideration of the use of low separator pressures as against the use of tank vapor recovery systems, there are many situations where considerable economies can be effected by the use of elevated automatically controlled low pressure separators on a vacuum system. A careful consideration of the relative merits of the two methods for preventing the loss of valuable gasoline vapors will always be worth the effort required to make the investigation.

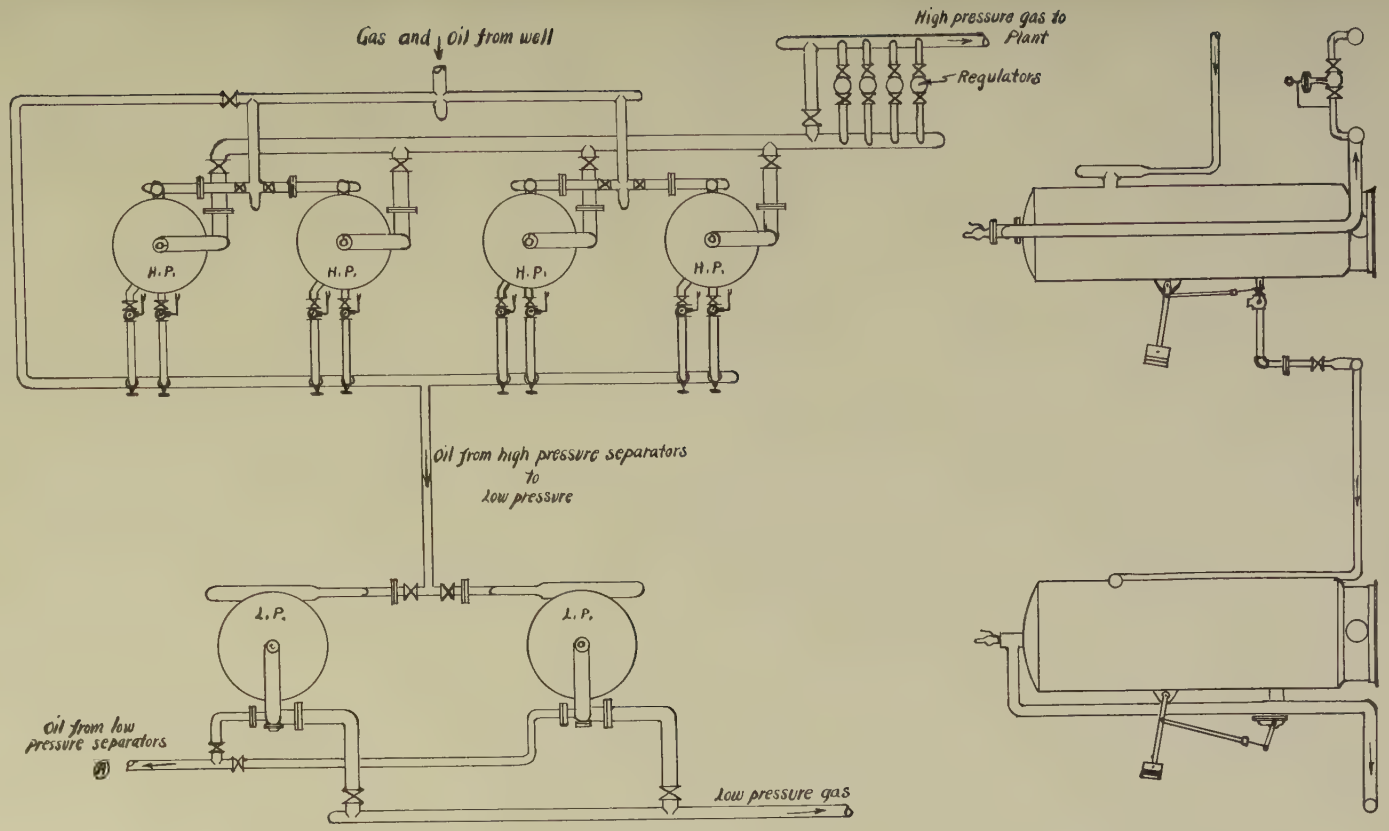

Gas and Oil from well
High pressure gas to Plant
Regulators
H.P.
H.P.
H.P.
H.P.
Oil from high pressure separators to low pressure
L.P.
L.P.
Oil from low pressure separators
Low pressure gas
Note. Elevation of low pressure separator should allow oil at (A) to gravitate to receiving tanks.

Figure 1

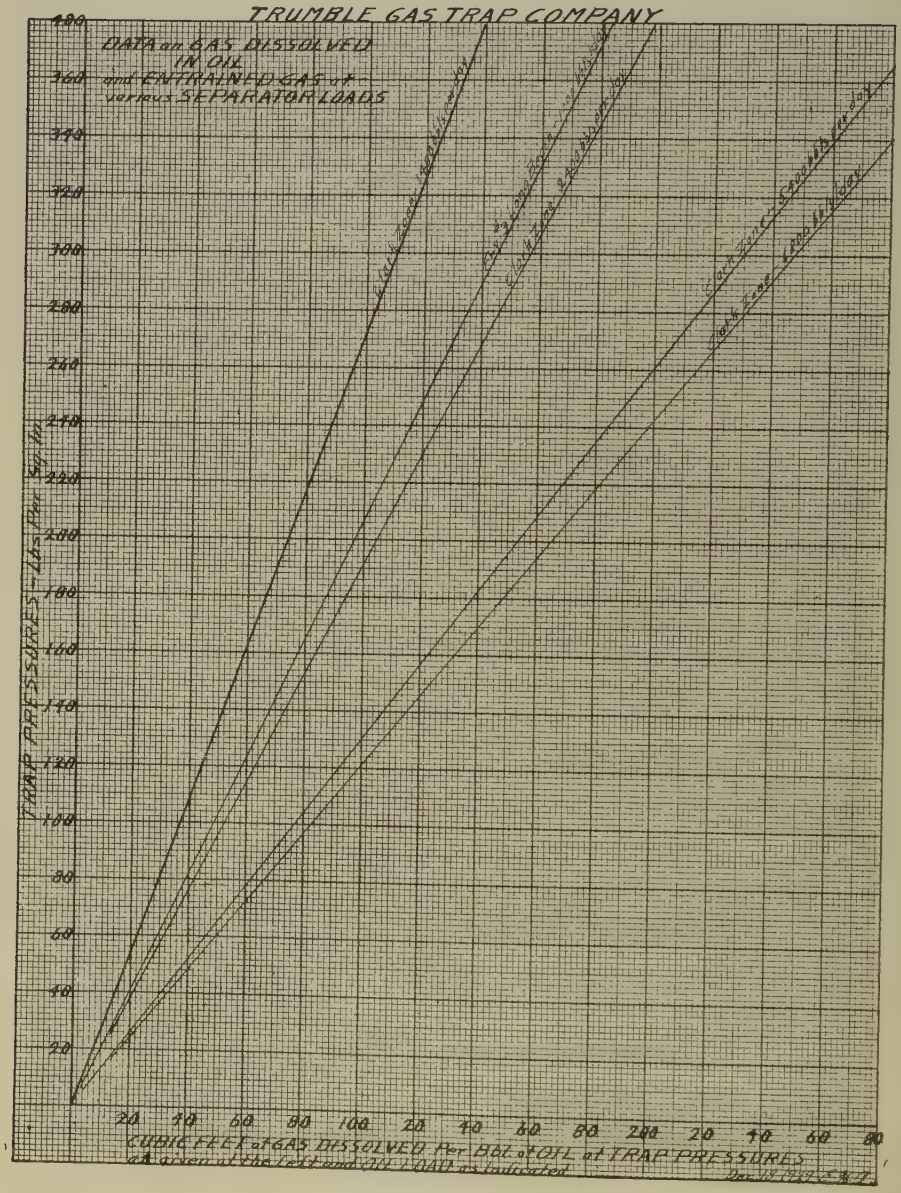

TRUMBLE GAS TRAP COMPANY
DATA on GAS DISSOLVED IN OIL and ENTRAINED GAS at various SEPARATOR LOADS
TRAP PRESSURES - Lbs. Per Sq. In.
CUBIC FEET of GAS DISSOLVED Per BBL of OIL at TRAP PRESSURES
as shown on the Gas and Oil Load as indicated

Figure 2

To facilitate the recovery of all possible gas under these conditions, it is advisable to have the separator at an elevation higher than the receiving tanks. With this arrangement the oil will gravitate from the separator to the tank and the separator can be operated at *atmospheric pressure*, or even at a few inches of vacuum.

In illustration of the factors to be considered when separator elevation is desirable — assume the separator to be connected to a line carrying 10″ Hg. vacuum or negative pressure; the distance to the receiving tanks to be 500 feet and the total length of riser line to the top of the tanks to be 20 feet; size of oil line 3 inches and equivalent valves, ells and tees to be equal to 100 feet, making total 3″ line equivalent to 600 feet. Now, if the well is making 100 bbls. per hour, we find a total friction loss for 600 feet of 3″ (from table 1) equal to (6 x .0512=) 0.31 pound. The back head due to riser (allowing 0.4 pound per square inch per foot of rise) is (20 x .4=) 8 pound per square inch. Pressure drop through oil control valve will be about 2 pounds per square inch — making total head required (.31+8+2=say) 12 pounds per square inch. Then allowing 0.4 pound per square inch per foot of rise, we divide 12 by 0.4 and find elevation head required is 30 feet without considering (5 (lb.) ÷ .4) 12 feet required to overcome 10″ vacuum pull upward on the oil. Therefore, in order to secure a minimum loss of valuable vapors by carrying atmospheric pressure on the separator, it would be necessary to elevate the separator in the derrick at a height of (30 + 12 =) 42 feet.

To approximate pressure drop for other gravity oil increase capacity of line for given pressure drop by 1% for every 3° A.P.I. above 38° and decrease capacity for given pressure drop by 1% for every 3° A.P.I. below 38°.

Many flow lines are exceedingly crooked. Where there are many sharp turns in the line, excessive pressure losses may result. The ordinary ell fitting has a resistance to flow approximately equal to 30 diameters of the line size. The ordinary tee fitting similarly is approximately equivalent to 60 diameters of the line size. Example — 8 elbows and 4 tees in a 6″ line. 6″ = 0.5′ so (8 x 30 x .5) + (4 x 60 x .5) = same resistance to flow as 240′ of 6″ pipe. Always make generous allowance for deposits of B.S., wax, or sand in the flow line, and for very short lengths of pipe between changes of direction.

Table (1)

Pressure Loss per 100 feet of 2″, 3″, 4″, and 6″ pipe
38° A.P.I. Oil of 100° F.

Barrels Per Hour	2″ Pipe	3″ Pipe	4″ Pipe	6″ Pipe
50	0.1138	0.0284	0.0047	0.0028
100	0.758	0.0512	0.0161	0.0047
200	2.08	0.265	0.0635	0.0083
300	4.68	0.587	0.139	0.0182
400	8.34	1.06	0.278	0.0337
500	12.8	1.65	0.393	0.053
600	18.4	2.46	0.586	0.075

Assume 0.4 pound per foot of rise for riser line or increase in elevation.

These factors and tables may be used in any case to determine the economies of various lengths and sizes of oil lines as well as elevation of separator to secure a minimum operating pressure usually desirable on single trap installations.

The operation of the low pressure separator at minimum pressure is made possible through the use of the automatic oil and gas control with which the separator is equipped, and which control will automatically restrict the gas outlet and thereby regulate its own pressure to force the oil out if the oil does not readily flow from the trap.

With this control arrangement the trap automatically builds enough pressure to put the oil into the tanks when the tanks are higher than the separator, and will continue to hold the required pressure for this purpose even though the gas gathering system is operated under vacuum.

Double Trap Installations.

The use of two separators in series for each well has recently come into more general use, and the natural horsepower of the well is used for the purpose of gas lift, repressuring, etc. The primary separation may be made at pressures ranging up to 725 pounds per square inch. The gas from the primary separator is delivered to the high pressure absorption plant, to gas lift wells, or the gas company as required, while the oil from the primary separator goes to a secondary separator, operated at atmospheric pressure, or at vacuum, where the final gas is removed.

The use of high separator pressures is frowned on by some operators, but like many oil field practices standard today and decried in the past — carrying of high separator pressures is rapidly gaining favor as more production men become acquainted with the advantages accruing therefrom, as follows:

(1) Practice by many large companies has established that the use of high separator pressures tends to increase production and flatten the decline curve.

(2) Steady down heading wells.

(3) Lower gas oil ratios. This has been found better practice than beaning back for this purpose — and

(4) It has been found an excellent method for controlling high pressure wells producing large quantities of sand; protecting flow beans, lead line manifolds, etc.

Second (only in order of notation) remarkable economies in respect to production and gas handling problems may be effected by using the high pressure gas thus made available for:

(5) Direct Gas lift purposes.

One specific instance brought to our attention has been the flowing of ten wells with the gas from a single high pressure separator without the use of compressors. This is one of many cases of similar gas lift operations in the Los Angeles basin.

(6) Direct repressuring of depleted zones for production and gas conservation purposes.

One company has put over 500,000,000 cubic feet of gas back into the upper zones at Santa Fe Springs directly from their high pressure separators without the use of compressors.

(7) High pressure absorption plant operation.

At Kettleman Hills gas is delivered directly from separators operating at from 500 to 600 pounds to absorption plants having a normal operating pressure of approximately 450 lbs.

(8) High pressure gas transmission to sale, or distant gas lift or repressuring operations.

For instance, the sale may be made possible by delivering the gas at high pressure and the increase in revenue would pay excellent returns on a high pressure installation.

The following table (Table 2) will illustrate to a limited extent this point. In this table are shown the comparative costs for installation and operation of a compressor plant to handle one million cubic feet of gas per day from certain pressures to pressures usually required for the operations listed under items (5) to (8) together with the costs involved in the installation of high pressure separators.

Other considerations permitting, it does not seem desirable to maintain high pressures behind the flow bean; separate the oil and gas at low

pressure; and then compress the gas at considerable cost back to the pressure already existing on the well. The available well pressure can be utilized by the slight increase in cost of the high pressure trap installation in comparison to the cost of the low pressure installation.

Table (2)

Comparative Costs of Compressors and High Pressure Separators.
Basis — One Million Cubic Feet of Gas Per Day.

Pressures From	Pressures To.	B. H. P. (1) Required	Compressors (1) Installed	Operation per day	Separation Installed	
20	200	106	$10,600.00	$17.00	$125.00	operation
200	500	51	5,100.00	8.00	175.00	costs
200	725	70	7,000.00	11.00	225.00	negligible
20	725	227	22,700.00	36.00	225.00	

(1) Approximate.

The general method of installation of both primary and secondary separator is much the same, with by-pass connections, emergency relief, etc., but nothing is gained by the elevation of the primary separator because the pressure is always present to force the oil from the receptacle. And with connections made as outlined heretofore, the primary separator may be removed and used elsewhere when the rock pressure diminishes to a point that makes unnecessary the further use of two stage separation.

An illustration of series double trap installation is shown in Fig. 3, while Fig. 4 shows a drawing of such arrangement. In Fig. 5 we have given a graph, and factors that may be of use in pipe line installation for the conveyance of gas. The curve given is for an initial pressure of 500 pounds per square inch for an 8″ pipe one mile long. The factors given will enable the

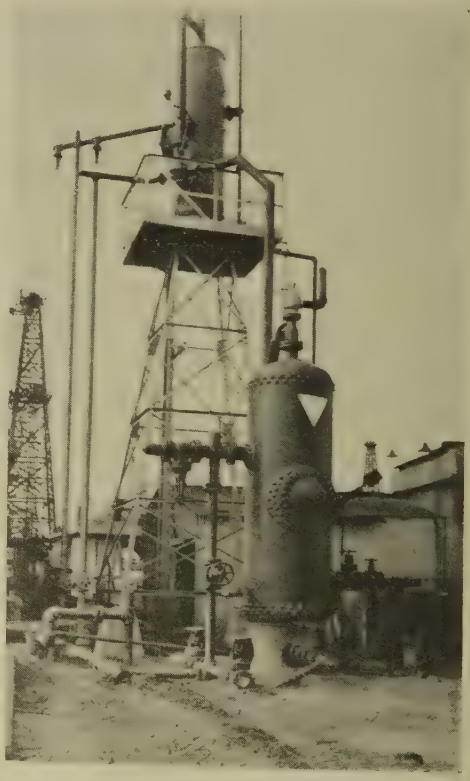


Fig. 3
Installation in series of Model "W" and Model "R" Separators.

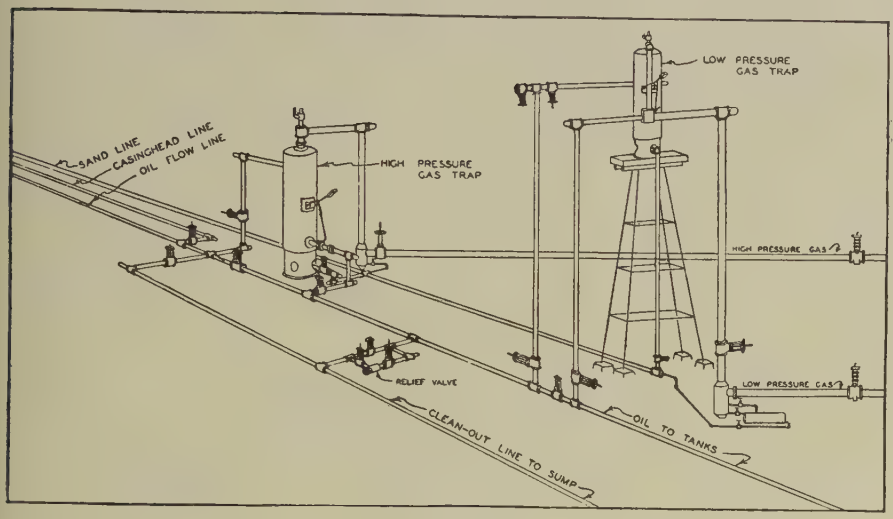


Figure 4

user to readily obtain the capacities for other size lines and for varying lengths and presure drops.

For example the capacity of a 6″ line, 2 miles long having an initial pressure of 400 lbs. per square inch with 300 lbs. pressure at the discharge end would be arrived at as follows:

The capacity of the 8″ line one mile long, initial pressure 500 pounds and pressure drop through the line 100 pounds is by Weymouth's formulae 67,500,000 cubic feet per day. Multiply this figure by the factors given for 6″ line; 400 pounds initial pressure and 2 miles of line. 100 lb. pressure drop on the 8″ line would give 67,500,000 cubic feet. Factor for 6″ line is 0.465. Factor for 400 pounds initial pressure is 0.900. Factor for 2 miles of line is 0.71. Therefore 67,500,000 x 0.465 x 0.900 x 0.71 = say 20,000,000 cubic feet per day as the capacity of the 6″ line.

Figure (6) is a graph the use of which will simplify the choosing of a suitable size pipe line for oil transmission and also will be of assistance in choosing a separator of suitable working pressure in cases where it is desirable to flow considerable volumes of oil for considerable distances without the use of pumps. Either the separator or the pump may be considered as a standby unit, but in many cases it may be found advantageous to use the free horsepower of the well as a power source for the moving of the oil.

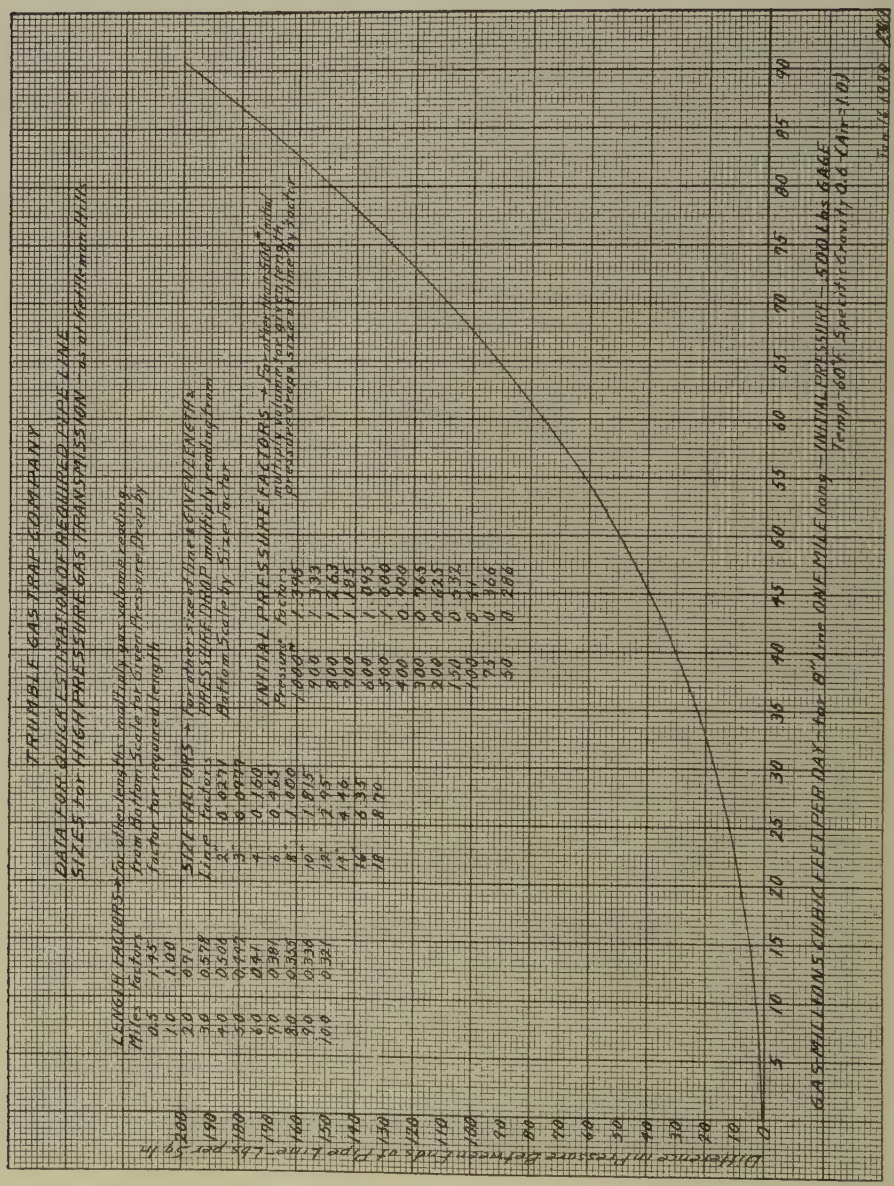

TRIUMPH GAS TRAP COMPANY
DATA FOR SIZING STATIONARY OR PORTABLE TYPE
SIZES FOR HIGH PRESSURE GAS TRANSMISSION LINE
CAPACITY FACTORS - for other than 6" pipe
Pipe Factor
Pipe Factor
SIZE FACTORS - for other sizes than 6" pipe
Pipe Factors
Diameter Factor
INITIAL PRESSURE FACTORS - for other than 100 lbs. gauge pressure
Pressure Factor
Differences in Pressure between Ends of Pipe Lines, in Pounds per Sq. In.
GASOLINE CONTENT IN GALLONS PER DAY - for 6" Line ONE MILE long - INITIAL PRESSURE - 500 LBS GAGE
Temp. 60° Specific Gravity 0.6 (Air=1.0)

Figure 5

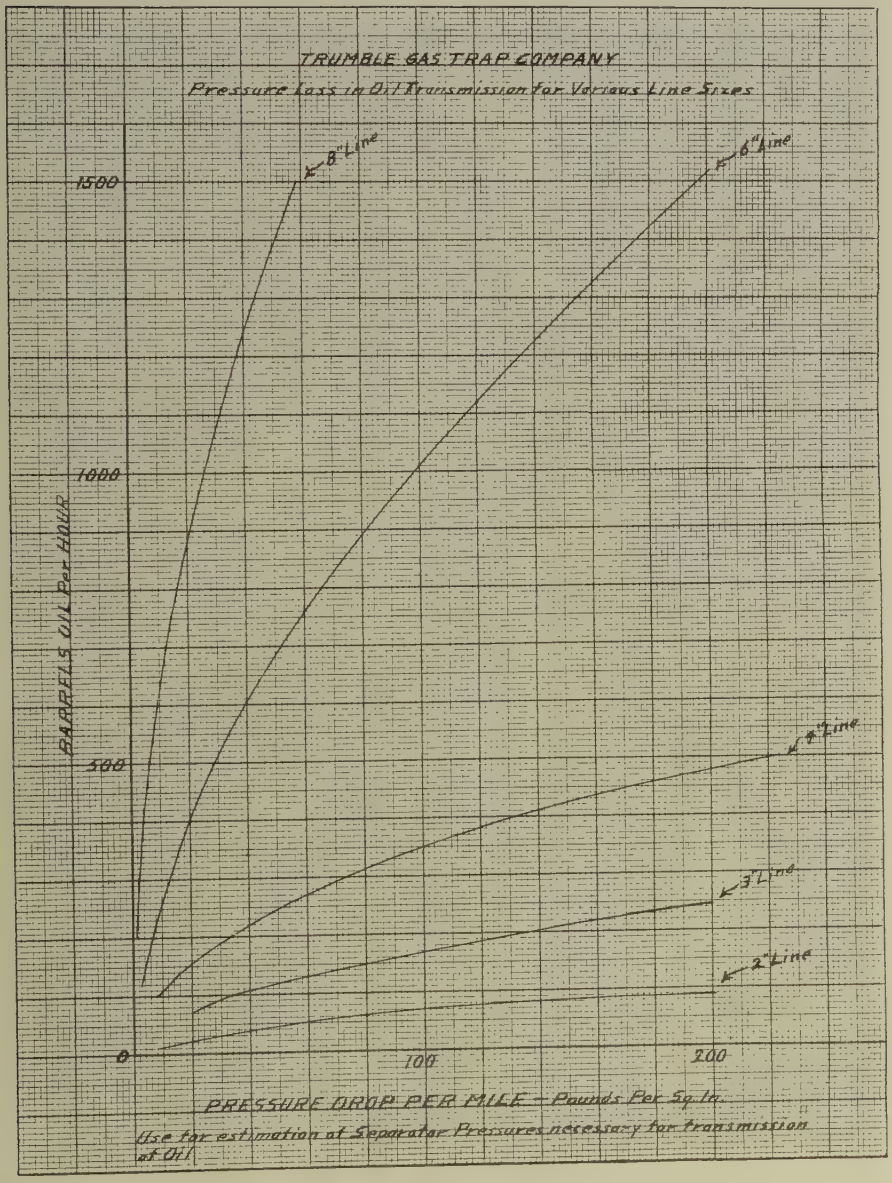

TRUMBLE GAS TRAP COMPANY
Pressure Loss in Oil Transmission for Various Line Sizes
8" Line
6" Line
4" Line
3" Line
2" Line
1500
1000
500
0
100
200
BARRELS OIL Per HOUR
PRESSURE DROP PER MILE - Pounds Per Sq. In.
Use for estimation of Separator Pressures necessary for transmission of Oil

Figure 6

OPERATION

WHEN a separator is installed and ready to operate there are a few minor points usually observed by operators to insure the separator's immediate response to the introduction of the oil and gas. The float is in a lowered position, with just enough tension on the connecting rod to assure the operator that the oil valve is closed. In this position no oil can leave the separator until the level of oil is built up high enough to raise the float, thereby opening the oil valve to let the oil flow out.

During this operation the gas will normally flow out through the gas line and into the absorption plant, or to the air, or such gathering system as arranged.

Should the operator wish a higher oil level in the separator, it is only necessary to secure this by turning the swivel nut on the connecting rod, thereby shortening the distance between the counterbalance lever (Float lever) and the lever on the valve. In normal operation the counterbalance lever should stand at a slight angle above the horizontal position.

The float in the separator has an equalizing pipe extending to the bottom for the purpose of equalizing the pressure inside the float, and the pressure should be *gradually* built up on the separator, allowing the pressure to communicate itself to the inside of the float to prevent collapse.

Should the low pressure separator discharge into a line at atmospheric pressure or vacuum and be so situated that a few pounds pressure will be necessary to discharge the oil from the separator, the automatic control will build this required pressure in the following manner. As the oil level engages the float and raises it the oil outlet port in the control valve is opened. However, for example, we will say that the receiving tank is slightly higher than the separator, and the oil does not flow out; as a result the separator continues to fill and the float rises higher. This continued rising of the float moves the slide plate over the gas outlet port toward a closed position, until the gas outlet is restricted sufficiently to build up a pressure in the separator. As the pressure reaches a point high enough to overcome the head, the oil starts to flow out and a balance is maintained between the pressure and head of oil. (See Fig. 7.)

It is, of course, an obvious consideration that a separator of highest separating efficiency should be chosen, and having determined this point that a separator of proper capacity be chosen. In this connection the characteristics of the well should be taken into account.

The ordinary capacity data for separators is given for steady flow, so,

if the well heads, that fact should be given due weight and a separator sufficiently large to give good separation during the heads should be selected.

For example, assume a well making 2,400 barrels of oil per day with 3,000,000 cubic feet of gas. The gas capacity graphs (Figs. 8 and 8-A)

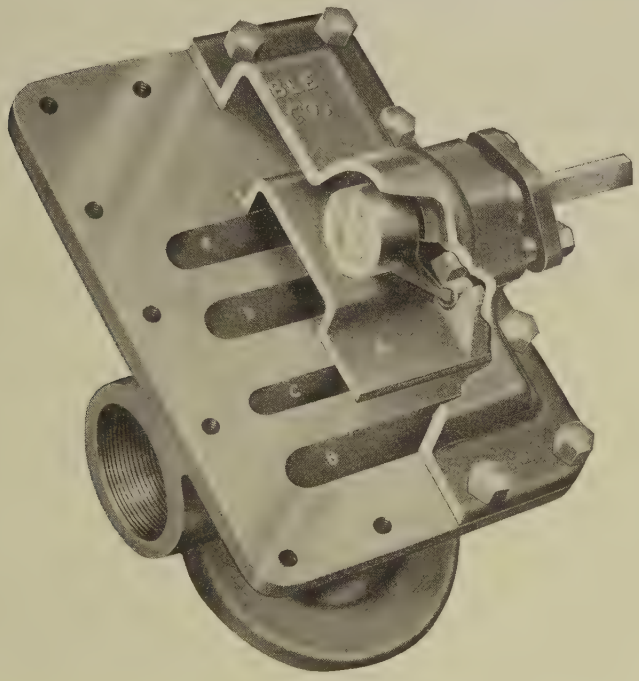


Figure 7

indicate that a 34 inch separator would be satisfactory. However, observation determines that the well heads for appreciable periods at a rate of 6,000,000 cubic feet per day. Then in order to secure a minimum carry-over of oil into the gas line it is obvious from the gas capacity graphs that a 42 inch separator should be installed. As the oil also comes in slugs, the installation of the 42 inch separator would also minimize the gas entrained in the oil going to the tanks.

These factors are worthy of careful consideration because of the troubles and inefficiencies to auxiliary operation that can be caused by excessive oil carry-over into the gas lines; and the "by-passing" of gas through the separator to the field tanks. A brief discussion of this follows:

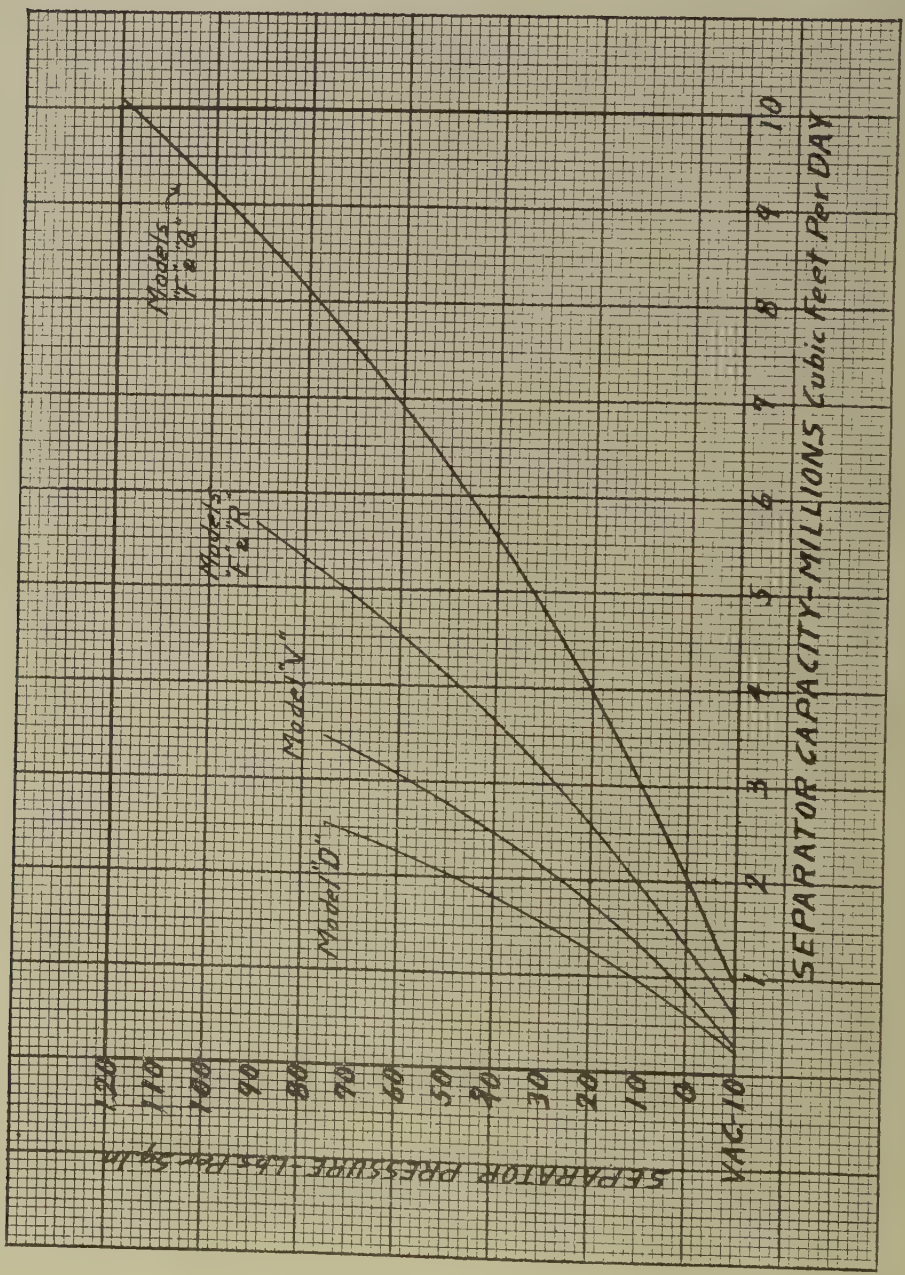

SEPARATOR PRESSURE Lbs. Per Sq. In.
VAC 10
0
10
20
30
40
50
60
70
80
90
100
110
120
SEPARATOR CAPACITY-MILLIONS Cubic Feet Per DAY
1
2
3
4
5
6
7
8
9
10
Model "V"
Model "D"

Figure 8

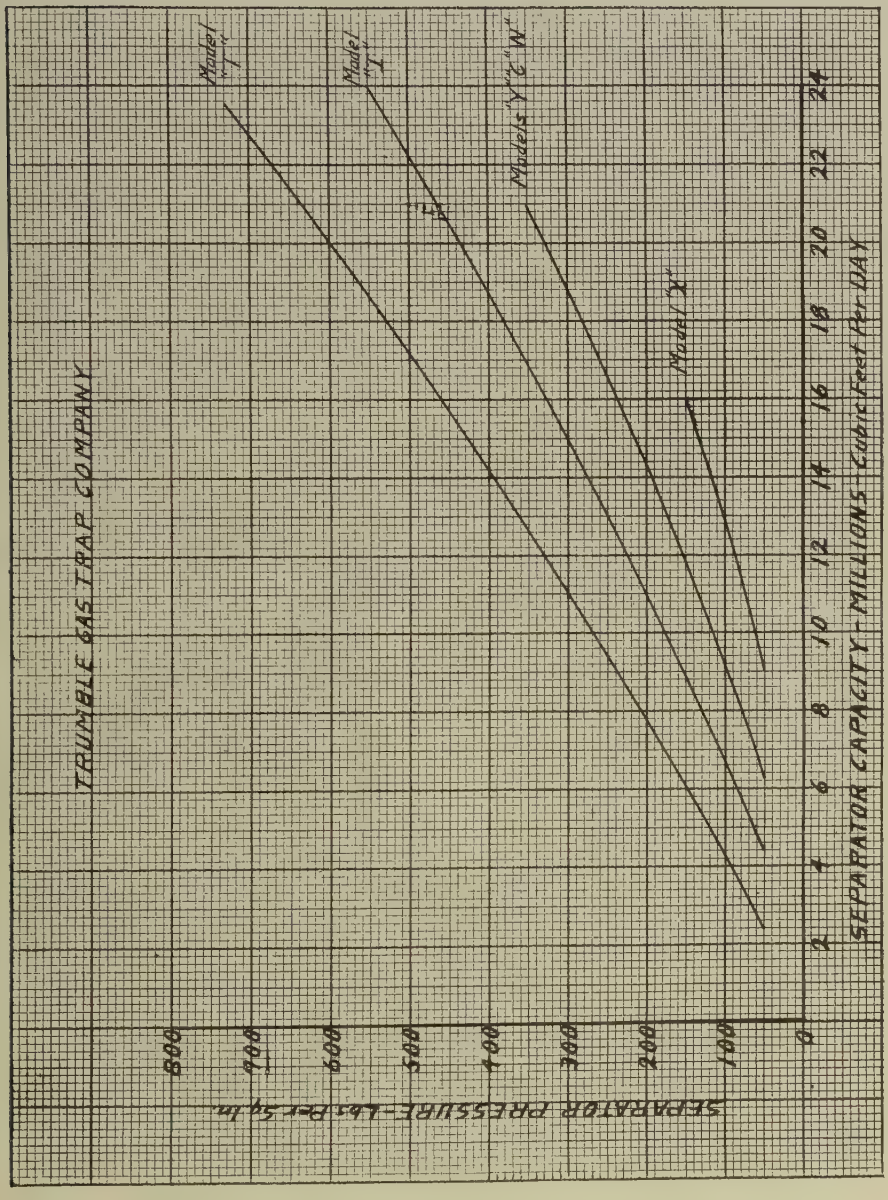

TRUMBLE GAS TRAP COMPANY
SEPARATOR PRESSURE-Lbs. Per Sq. In.
SEPARATOR CAPACITY-MILLIONS Cubic Feet Per DAY
Model "X"
Models "Y" "Z" "W"
Model "I"
Model "I"
800
700
600
500
400
300
200
100
0
2
4
6
8
10
12
14
16
18
20
22
24

Figure 8A

Oil carried over into the gas line may find its way into the absorption plant where serious contamination of the absorption oil may eventually result. Absorption oil contaminated with crude rapidly looses its absorptive ability and serious loss of the most desired natural gasoline fractions of the gas results. This difficulty can be largely eliminated by the proper selection of efficient separators of the right size for the production characteristics and operating pressure. This precaution together with the installation of efficient gas scrubbers on the inlet and outlet of the absorption plant will give the very desirable result of minimum trouble and, of prime importance, minimum loss of revenue.

The carry-over of oil into the gas lines from inefficient or overloaded separators can also cause much trouble in the gas transmission lines — either vacuum or pressure lines. Oil accumulates in the low places in the lines and when conditions are right the oil surges through with the gas and unless proper precautions are taken may cause boiler plant explosions and very serious damage to compressor plant installations. The use of good scrubbers on gas lines is always desirable — the scrubber to be installed immediately ahead of the operating unit.

Carry-over is particularly obnoxious in vacuum line systems. The effect is to diminish the size of the line which rapidly increases the compressor horsepower necessary to move the gas under negative pressure. One investigation, resulting in the removal of the oil from the lines, permitted the removal of two 80 horsepower compressors to another operation and actually lightened the load on the remaining units. Good drips should be installed at all low places in the line, which together with the use of efficient scrubbers of proper size and efficient separators of proper size will assure a minimum of trouble and loss.

Gas "by-passing" or going through the separator with the oil to the receiving tanks will by mechanical agitation of the oil and diminishing of the partial pressure of the light oil fraction vapors — cause excessive and unnecessary losses of gasoline vapors from the tanks with resulting lowering of the gravity of the crude. This effect is aggravated by the presence of water vapor in the gases, as is the case when the oil has an appreciable water cut.

Fig. 9 is a graph showing the gas dissolved and entrained per barrel of oil at various separator operating pressures and the relation between the operating pressure of the high pressure separator and the natural gasoline content of the gas recovered from the atmospheric pressure separator. The gasoline content is expressed as Gallons of "Normal

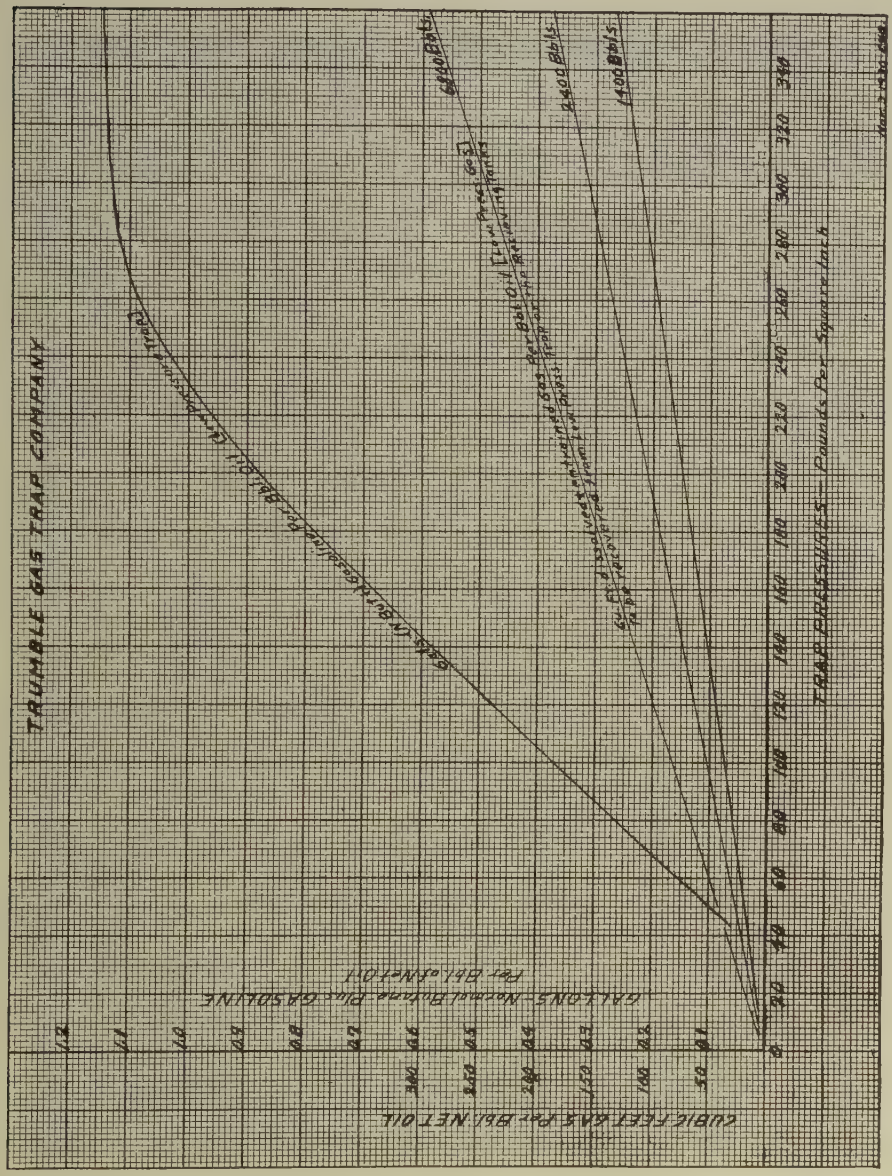

TRUMBLE GAS TRAP COMPANY
TRAP PRESSURES—Pounds Per Square Inch
GALLONS—Normal Butane Plus GASOLINE Per Bbl. of NET OIL
CUBIC FEET GAS Per Bbl. NET OIL
Gasoline Content of Gas in Gallons per M. Cubic Feet
Gasoline Content of Gas in Gallons per Barrel of Oil
Gas-Oil Ratio in Cubic Feet per Barrel of Oil
1000 Bbls.
2500 Bbls.
5000 Bbls.

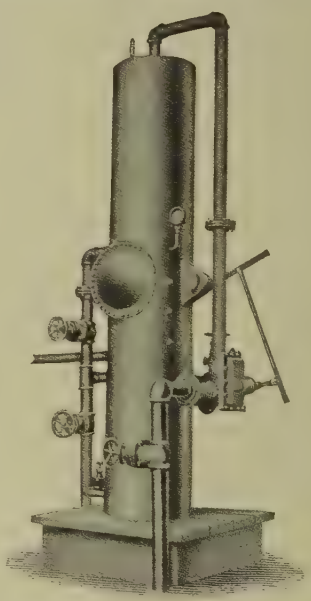
Figure 9

Butane-Plus Gasoline" per Barrel of Oil passing through the low pressure separator.

Assume 2,400 barrels of oil per day; high pressure separator 300 pounds per square inch; low pressure separator atmospheric (approximately). Then the gas content of the oil is 156 cubic feet per barrel; the "N But + " gasoline content is 1.1 + gallons per barrel and the gasoline recovery may approximate 2400 x 1.1 = 2640 gallons of commercial natural gasoline per day. Or expressed as gallons per thousand cubic feet, this becomes 2400 x 156 = 374,000 cubic feet of gas; and 2640 divided by 374 = approximately 7 gallons per thousand cubic feet in the gas from the low pressure separator.

In consideration of the gasoline content of the low pressure gas — it is evident that it will vary with the pressure on the high pressure separator as well as with the quality of the oil handled. Also, it has been found that oil cutting considerable water will yield a gas with a gasoline content much above the average — sometimes running as high as 12 to 14 gallons per thousand; and 9 and 10 gallons per thousand is very common content.

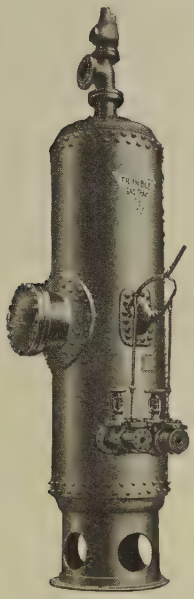
Bearing this in mind, it is easy to see the economies that may be secured by carefully considered oil and gas separation. Assume for instance a production of 2400 barrels per day of net oil having a high water content, and a single separator pressure of 50 pounds per square inch. At 50 pounds the oil will contain about 25 cubic feet of gas per barrel (Fig. 2) containing say 12 gallons of gasoline per thousand cubic feet. Then 2400 x 25 = 60,000 cubic feet per day; and 60 x 12 = 720 gallons of gasoline per day which would be lost from the tanks, if no waste vapor recovery system was used.



Model "D" Separator for 75 pound maximum working pressure.

This condition is aggravated in the tanks by the agitation and large surface exposed so that materially greater losses might be expected.

The higher gasoline content of gas from wet oil as compared to gas from dry oil is explained by a consideration of the effect of the partial presure of the water vapor upon the partial pressures of the gasoline vapors. Or in effect the tanks become low pressure, low



Model "I" Separator for 525 lbs. working pressure.

temperature steam stills. It would seem good practice to recover these vapors at the low pressure trap whenever possible, either by double trapping or by elevating the low pressure separator so that operation at atmospheric pressure may be secured.

SAND

LARGE quantities of sand carried in the oil body has been the source of more or less trouble in separator operation. It is common knowledge that quantities of sand carried in oil and gas at high velocities will cut out or wear away any substance. As a result a well making large quantities of sand will cut out beans at a fast rate. When the separator is operated at high pressure the oil outlet valve receives the cutting action from that portion of the sand that remains in suspension in the oil. If the volume of oil handled is large, the length of time that the oil remains in the separator is not sufficient to settle out all of the sand and consequently a portion is carried through the oil control valve with resulting abrasion.

To obtain unbroken operation under these conditions the models "T" and "I" separators are fitted with oil outlet valves in duplicate with gate valves between the control valves and the separator. With this arrangement one control valve can be used and if it cuts out so that it becomes necessary to repair it, the oil can be switched to the second valve and the first one can be removed or repaired while the separator continues in uninterrupted service.

To secure the best possible resistance to abrasion the seats and plugs of the balanced valves used on the models "I" and "T" are made of tool steel and this tool steel is hardened. The seats and plugs are removable to facilitate repairs and they are kept in stock and can be shipped out for change in the district where the separator is operated. The seats are pressed into the valve and the plugs are then ground in to a perfect seat.

The slide valve is an alternative that may be used on the Models "I" and "T", but as the pressure on this valve increases, the friction becomes greater and the port opening through the valve plate must be small to prevent the friction becoming too great for float operation. With the use of the slide valve a port insert plate may be used and this insert plate, with slide plate when worn, constitutes the only change necessary for a cut out valve.

To minimize the cutting action of the sand it has been found good practice to calculate the proper size of orifice in the insert plate for the oil volume and separator operating pressure conditions. These precautions need be taken only when the abrasive action is very severe and is applicable only to specific cases.

The low pressure separators with the oil and gas control have been used under varying sand conditions with complete success. While large quantities of sand carried in the oil under pressure will eventually cut out the valve, in cases of operation with large quantities of sand with a differential of 35 lbs. or a pressure drop of 35 lbs. through the valve, the double control has operated many months without losing its efficiency.

It should be noted that all of the slide valves, as well as the balanced valve, may be repaired in the field, when severe sand conditions make repair necessary, by the use of insert plates and new control slides if needed. Thus a convenient and economical repair is made possible.

To minimize the cutting action it is always well to keep the pressure drop through the valve as low as is possible when sand is present.

The intermediate pressure models—150 lbs. to 350 lbs. are ordinarily equipped with a 4″ slide valve, but the oil outlet is double so that two oil outlet valves may be used if required; the arrangement being similar to the models "I" and "T".

CAPACITY

THE capacity of separators depends upon the volume of oil, volume of gas, gravity of oil, and operating pressure. But the volume of gas and the operating pressure are the most important factors to deal with. Within certain limits the amount of oil may vary without greatly affecting the separation, and for a 42″ diameter separator the amount may vary from a few barrels per day to say 2,000 barrels per day, and the dryness of the gas will remain the same.

However, the amount of gas in the outgoing oil will show an increase with the increased volume handled. In other words, in addition to the amount of gas dissolved in the oil under the operating pressure, a certain amount of gas will be carried through in the form of minute gas bubbles that are entrained in the oil and the time element is not sufficient to liberate them in the receptacle. With a decreased throughput, the oil body remains in the separator for a longer period and more of the gas is released. (See Fig. 2)

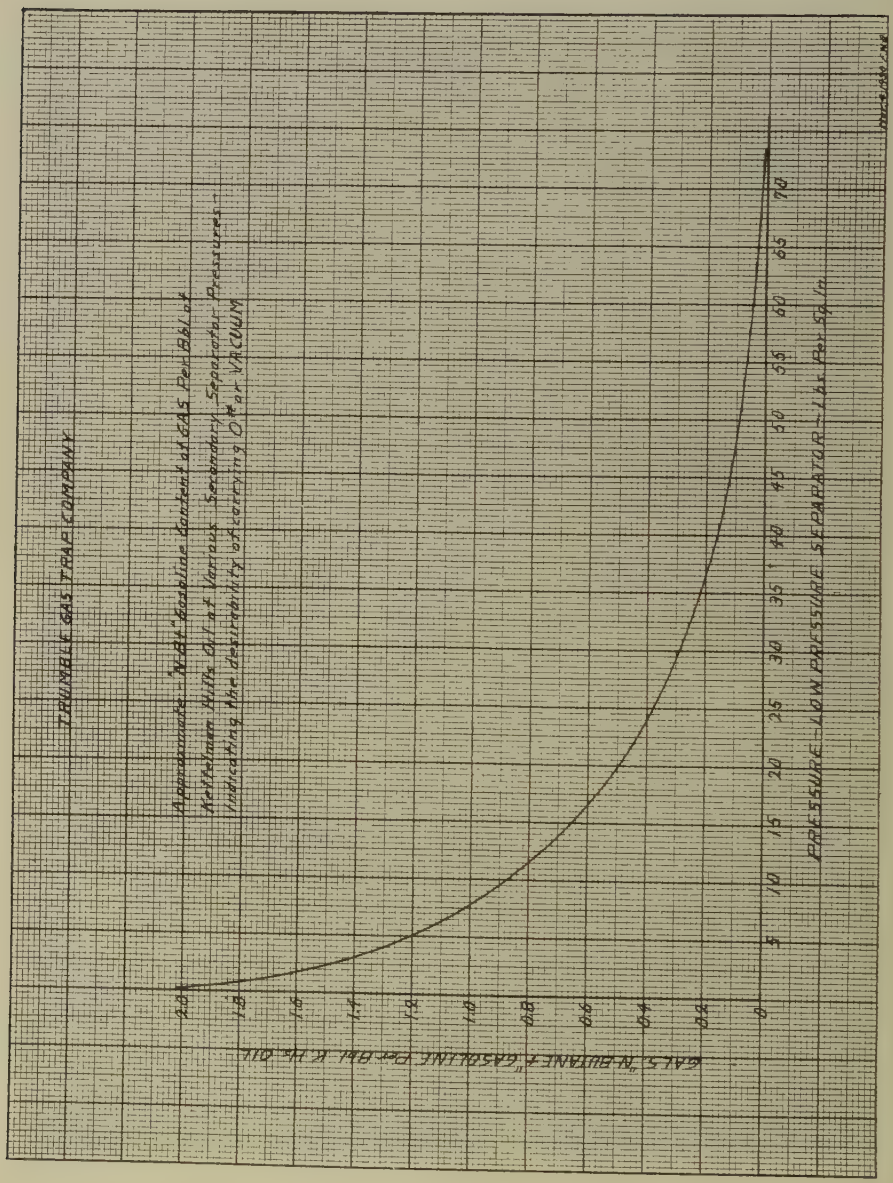
With the oil of heavier specific gravity the separation is more easily effected, because of the greater difference in specific gravity between the oil and gas.

However, it is with the volume of gas and the operating pressure that we are mainly concerned in the selection of a suitable separator, and the graphs in (Fig. 8) will give a fair range of capacities that are fairly accurate for good separation with an average grade of oil.

A perusal of Fig. (2), will show the benefit of an elevated secondary separator to secure a low operating pressure and a fairly accurate estimate may be made of the volume of gas to be extracted from the secondary separator or from the tanks if no secondary separator is used.

Some variation may be expected with oils of varying specific gravities, but these figures will be found close enough for estimating purposes. For example—

> Assume the primary high pressure separator to be operating at 350 pounds per square inch and the oil rate to be 2,400 barrels per day. From the graph we find it should be expected that the oil going to the secondary low pressure separator operating at atmospheric pressure will contain 182 cubic feet of gas per barrel and by multiplying 2,400 barrels of oil per day by 182, the volume of 436,000 cubic feet per day is secured as the volume of gas to be received from the low pressure trap.


TRUMBLE GAS TRAP COMPANY
Approximate "N.G.P." Gasoline Content in GALS Per 1000 Cu. Ft.
of Rich Natural Gas at Various Separator Pressures
Indicating the Desirability of Carrying a Low VACUUM
GALS "N BUTANE & "GASOLINE Per BBL. of the Oil
PRESSURE-LOW PRESSURE SEPARATOR-Lbs. Per Sq. In.

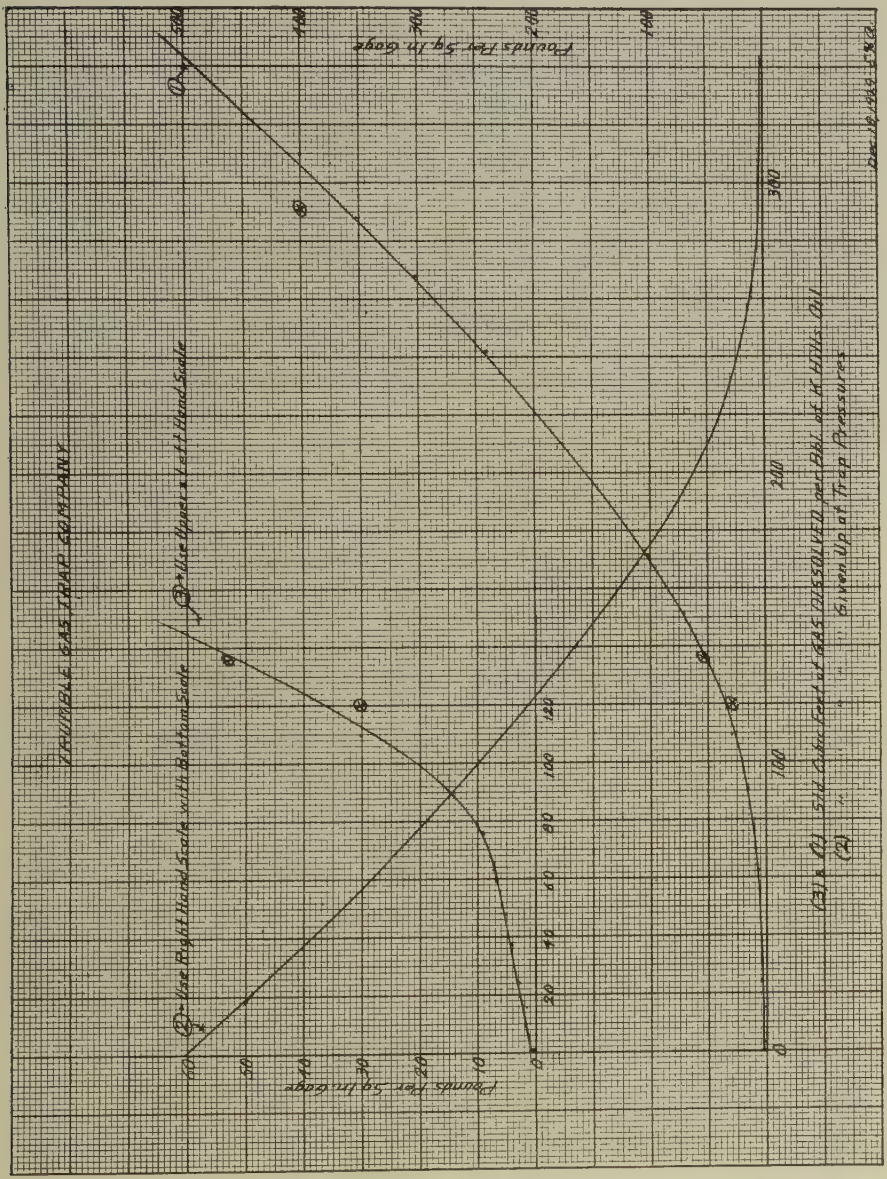

Pounds Per Sq In Gage
Pounds Per Sq In Gage
Use Right Hand Scale with Bottom Scale
Use Upper Left Hand Scale
Available Gas from Separator
Pressure Drop Between Separators
Gives Up at Trap Pressures
Dec. 16, 1941

TABLE 3—EFFECT OF DECREASING SECONDARY TRAP PRESSURES ON FIVE NEW WELLS AT SANTA FE SPRINGS

Well No.	Trap Pressure (lbs.)	Gas production (mcf./24 hrs.)	Yield per mcf.	Total gasoline production	Total Increase in gasoline production
1	38	919	3.44	3,165	
1	16	1,253	4.99	6,250	3,085
2	43	1,076	3.51	3,779	
2	16	1,578	6.23	9,826	6,047
3	38	876	3.77	3,303	
3	8	1,157	5.79	6,701	3,398
4	38	1,527	3.21	4,900	
4	14	1,977	4.70	9,296	4,396
5	30	600	4.60	2,760	
5	12	800	6.00	4,800	2,040

TABLE 4—PERFORMANCE DATA OF WELLS PRODUCING FROM NORDSTROM AND BUCKBEE ZONES

Well No.	Oil prod. per 24 hrs. (bbls.)	Total gas-oil ratio	Primary trap data					Dissolved and entrained gas in oil to secondary trap (Cf. per bbl.)	Secondary trap data				
			Temp.	Press.	Mcf.	G.P.M.	Gasoline produced		Temp.	Press.	Mcf.	G.P.M.	Gasoline produced
1	5,155	2,819	128	300	13,279	1.02	13,545	243	96	16	1,253	4.99	6,250
2	4,067	1,256	132	300	3,531	1.16	4,114	387	109	16	1,578	6.23	9,826
3	4,175	1,518	131	300	5,182	1.01	5,244	277	112	8	1,157	5.79	6,701
4	5,826	4,430	123	300	23,825	0.80	19,060	340	104	14	1,977	4.70	9,296
5	2,622	3,775	125	200	9,545	1.36	12,981	135	95	7	353	5.91	2,086
6	3,326	3,165	122	200	9,945	1.39	13,824	175	92	8	583	5.89	3,434

"Trend in Gas Trap Construction is Toward Decrease in Baffling."
C. C. Taylor, Assistant Gas Superintendent, Southern Division of Union Oil Co. of California.

SCRUBBERS

THE use of gas scrubbers, the primary function of which is to remove small amounts of finely divided or atomized oil mist and water from the gas stream has been briefly touched upon.

In general, the use of scrubbing equipment is familiar to all operators in connection with absorption plant, compressor plant, and boiler plant operation. However, it may be well to point out that it is possible that not sufficient thought and care has been exercised in the past in the selection of proper scrubbing equipment. At the present time considerable deserved attention is being given to their installation.

It has been said that "any old tank will do", but recent experiments and continued study of the economic factors of all phases of operations have demonstrated that such an idea is quite seriously in error.

As pointed out above, the lack of scrubbers or the use of improper scrubbing equipment can result not only in unnecessary economic losses but in some cases in the creation of hazards to life as well as property.

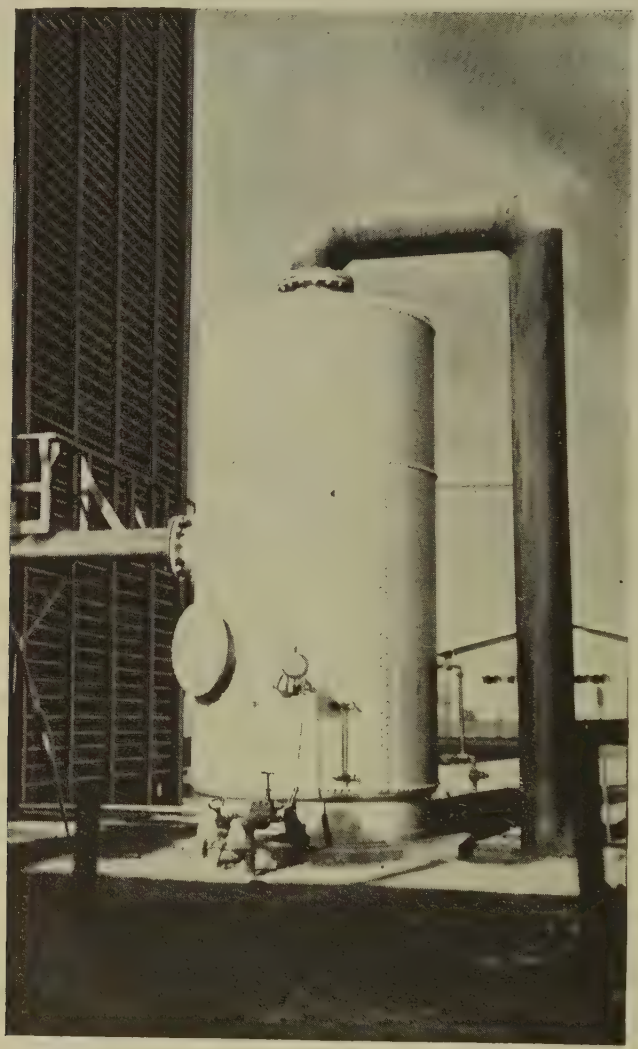
At this point we might ask ourselves just what it is that we expect from this piece of equipment, and then whether or not there are any known principles that we may use in its construction to secure the maximum efficiency.

We find that we want an apparatus to handle large volumes of gas and to separate from this gas, oil which will come through with it, probably in the form of small slugs. In other words, it will require an oil and gas separator of sufficient size to handle the load.

We should say that in this case, the name scrubber is a misnomer. The word has evidently been taken from the piece of absorption plant equipment bearing that name. The scrubber as used in absorption plants has a system of baffles for the purpose of changing the direction of flow and impinging the gas against exposed surfaces to which the moisture in the gas may adhere and then the accumulation may be trapped out. But we also know that the capacity of such a piece of apparatus is limited to a very small throughput, and when this is exceeded, the increased velocity sweeps all moisture along with it and the efficiency of the scrubber is lost.

However, in applying the separating principle to scrubbers, which are really separators for separating small quantities of oil from large volumes of gas, we decrease the velocity to the greatest extent, and the scrubber is constructed with an incoming spreading baffle for the purpose of giving an even distribution of the incoming oil and gas over

the walls of the receptacle. From this point on, the gas is allowed to rise to the outlet without further baffling and with the lowest possible velocity, which action drops out any remaining moisture, and if the scrubber is not over loaded, the issuing gas is dry.



Scrubber used on discharge of compressor plant for collection of gasoline.

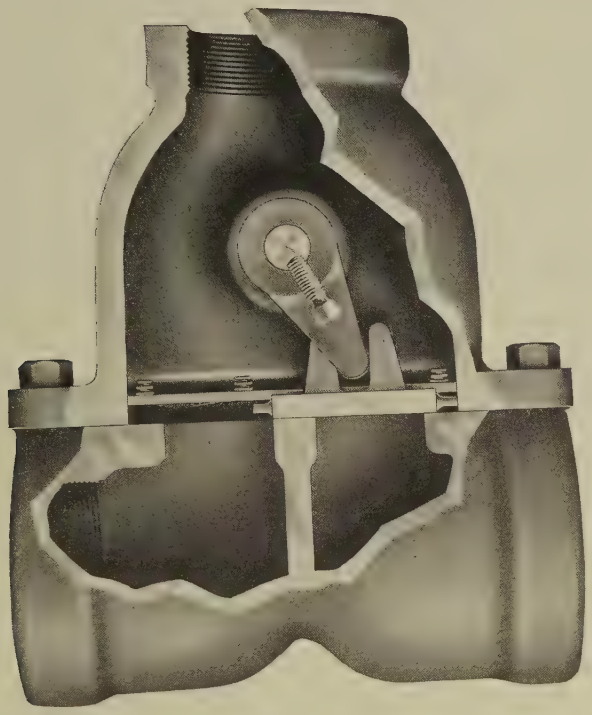


Figure 10

TANK SWITCHING VALVES

A REFERENCE has been made to valves for the purpose of switching the oil flow from the separator to the respective tanks. This is of more than minor importance because on some known occasions separators have been shut in by closing the valve to one receiving tank, and then for some reason failing to open the valve to the other tank. On such occasions the oil builds up in the separator until it must be discharged, either into the gas line or through the pop safety valve, resulting in the loss of oil as well as creating a serious fire hazard. If the pop valve is not adequate to relieve the accumulation, the full well pressure may build upon the separator with the possibility of explosion and the creation of a serious fire hazard, and what is still more serious, place human life in jeopardy.

If gate switching valves are used, a precautionary measure would be the installation of an oil line relief valve between the separators and the tanks. This relief valve, set at a relieving pressure a few pounds less

than the operating pressure, would open into an otherwise valveless line to the tanks.

To meet this problem a two-way tank switching valve has been developed to eliminate the possibility of shutting in the separator. An illustration of this valve is shown in (Fig. 10) and an examination of its construction will show that it cannot be closed to both tanks at the same time. Observe that when the slide plate moves to close off the flow to one tank, it begins at the same time to open the flow to the other. During the operation there is a point where it is momentarily open to both tanks, but at no time is the flow to both tanks shut off.

POP SAFETY VALVES

THE question of pop safety valves for separators is receiving more attention than it has in the past, and it is deserving of such attention. There is always a possibility that through an error of some kind a separator may be shut in, and in such case the pop safety valve will be called upon to relieve the entire flow into the separator. To provide for this the pop valve should be of sufficient capacity to relieve the maximum load that the separator may be called upon to handle.

For pressures greater than 300 pounds it is advisable that the body of the valve should be of cast steel.

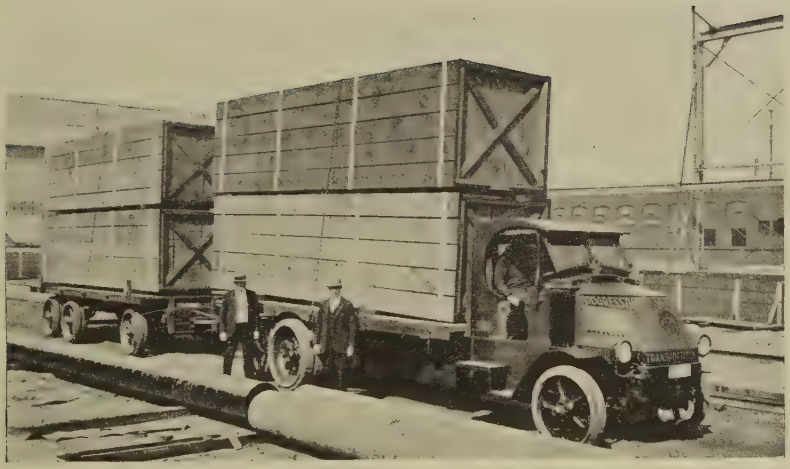
All pop safety valves should be fitted with a lever whereby the valve may be regularly tested to ascertain that it is in operating condition.

EXPORT

PACKING of separators, valves, etc., for export shipment should receive some little attention. Boxes for equipment should be built of material sufficiently strong to ensure the package arriving at its destination intact.

This same consideration holds true of large equipment as well as small; a separator is subject to rough handling in loading and unloading and complete boxing with 2″ lumber prevents the damaging of auxilliary equipment on the separator.

Many uses are also found for the boards used in the packing cases when the separators and equipment are finally unpacked.



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